UNIVERSITÉ DU QUÉBEC À MONTRÉAL

RÉPARTITION DE L'EIDER À DUVET PENDANT LES PÉRIODES D'ÉLEVAGE DES JEUNES ET DE MUE DES ADULTES LE LONG DU FLEUVE SAINT-LAURENT

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HÉLÈNE DIÉVAL

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AVANT-PROPOS

Ce mémoire est constitué de deux chapitres rédigés en anglais qui seront soumis pour publication dans des revues scientifiques. Je suis le premier auteur pour ces deux articles, Jean-François Giroux, mon directeur de recherche est deuxième auteur et Jean-Pierre L. Savard, mon co-directeur, est troisième auteur. Ces deux chapitres sont précédés par une introduction générale et suivis d'une conclusion générale. Certaines données récoltées et non traitées dans les deux chapitres sont soumises en annexe. J'ai effectué les prises de données sur le terrain durant les étés 2003 et 2004, je les ai moi-même analysées et j'ai rédigé les deux manuscrits.

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RÉSUMÉ

Les effectifs de la population d'Eiders à duvet (*Somateria mollissima dresseri*) de l'estuaire du Saint-Laurent fluctuent considérablement sans tendance apparente depuis plusieurs années. Pendant l'été, les périodes d'élevage des jeunes et de mue des adultes sont deux moments importants du cycle de vie de cette espèce. La sélection d'habitats optimaux appropriés à leurs besoins est alors primordiale. La moindre modification de ces habitats, notamment par le développement anthropique, pourrait jouer un rôle important dans le devenir de toute la population. Les objectifs de notre étude étaient d'étudier la répartition et le comportement des eiders sur les sites d'élevage des jeunes et de mue des adultes sous l'influence de facteurs biotiques et abiotiques le long de la rive sud de l'estuaire du Saint-Laurent.

Le terrain d'étude s'étendait sur 200 km entre les municipalités de Notre-Dame-du-Portage et de Matane dans la région du Bas Saint-Laurent. Des inventaires ont été effectués dans 68 zones d'observation le long de la côte, tous les trois jours. Le nombre d'oiseaux, l'âge des jeunes, le sexe des adultes et leur comportement ont été notés, ainsi que l'occurrence du dérangement humain. La disponibilité des ressources alimentaires a été obtenue sur le terrain par une caractérisation des habitats à l'aide d'une série de transects établis aléatoirement dans un sous-échantillon de zones. Les couvées et les adultes sans jeunes avaient une répartition distincte principalement influencée par la répartition et l'abondance de leurs proies préférentielles. Les couvées privilégiaient les côtes proches des îles de nidification tandis que les adultes partaient en direction du Golfe du Saint-Laurent très tôt après l'éclosion. Leur comportement sur les rives variait également selon leurs besoins énergétiques respectifs mais aussi, pour tous les oiseaux, sous l'influence du dérangement humain.

Cette étude a caractérisé les sites préférentiels d'élevage des jeunes le long de la rive sud du fleuve Saint-Laurent. Elle a également révélé que la majorité des adultes ne mue pas dans cette partie de l'estuaire. Ces connaissances faciliteront la mise en place de plans de gestion pour la conservation de cette espèce. Néanmoins, d'autres études sont à mener pour identifier les principaux sites de mue des adultes et caractériser plus précisément l'influence de variables abiotiques comme le dérangement humain sur les couvées d'eiders.

Mots-clés : *Somateria mollissima*, élevage des jeunes, mue, répartition, ressources alimentaires

INTRODUCTION GÉNÉRALE

Sélection de l'habitat

Pour l'ensemble du règne animal, la sélection de l'habitat dépend du cycle vital de l'organisme (Cody 1985). Le monde scientifique s'accorde à dire que cette sélection d'habitat est faite afin d'optimiser la valeur adaptative de chaque individu. Si on s'attache au cas particulier des oiseaux, on remarque que c'est sans doute la catégorie la plus mobile du règne animal. Ainsi, parmi tous les habitats que ceux-ci peuvent rencontrer ou survoler, ils effectuent un choix spécifique selon qu'ils sont en période de nidification, d'élevage des jeunes, de préparation à la mue ou de migration (pour les oiseaux concernés par des migrations saisonnières). Les aires de nidification, par exemple, présentent généralement une protection contre les prédateurs et contre les mauvaises conditions météorologiques qui peuvent entraîner des pertes de chaleur pendant l'incubation des œufs et ainsi influencer la réussite de l'éclosion (Kilpi et Lindström 1997 ; Chubbs et al. 2000). Les zones d'alimentation présentent des ressources alimentaires préférentielles en quantité et en qualité dans les moments où les individus doivent optimiser leur prise énergétique. Par exemple, la période de mue nécessite un apport de nutriments ainsi qu'un abri contre les prédateurs car les oiseaux, ne pouvant voler, sont plus vulnérables à la prédation.

Si on s'intéresse aux sites d'élevage des jeunes, ceux-ci sont souvent différents des sites de nidification pour les espèces ayant des jeunes nidifuges (e.g. les jeunes quittent le nid à l'éclosion et s'alimentent seuls) (Bédard et al. 1986 ; Pehrsson et Kenneth Nyström 1988 ; Pöysä et Virtanen 1994). De plus, il faut savoir que la plupart des Ansériformes parcourent parfois de longues distances avant de rejoindre l'habitat optimal pour la croissance des juvéniles. Ainsi, Maisonneuve et al. (2000) ont montré que, dans le sud du Québec, les femelles et les jeunes des Canards noirs

(*Anas rubripes*) et des Canards colverts (*A. platyrhynchos*) non seulement sélectionnent des habitats d'élevage favorables, mais parcourent aussi des distances pouvant atteindre 7 km avant d'y accéder. Il faut savoir que les oisillons juste éclos ont besoin d'un important apport d'énergie afin d'optimiser leur croissance et leur survie face aux prédateurs. C'est à cette occasion que certains comportements particuliers se mettent en place comme le regroupement des individus en crèches (e.g. regroupement de jeunes de parents différents), phénomène qui se retrouve chez beaucoup d'espèces d'Anatidés (Beauchamp 1997) mais qui demeure encore inexpliqué. En effet, il permettrait d'augmenter le taux de survie des jeunes face aux prédateurs (Munro et Bédard 1977) et pourrait augmenter la valeur adaptative des femelles en mauvaise condition physique qui abandonnent leurs petits (Bustnes et al. 2002). Dans ce sens, il a été montré chez la Bernache du Canada (*Branta canadensis*) que les oisons légitimes ont un taux de survie supérieur, par rapport aux oisons adoptés, de par l'effet de groupe face au prédateur ainsi que par leur localisation centrale au sein de la crèche (Nastase et Sherry 1997). L'Eider à duvet (*Somateria mollissima*) est un canard marin qui privilégie ce système particulier d'élevage (Bédard et Munro 1977; Beauchamp 1997; Bustnes et al. 2002).

Système à l'étude

Il existe trois sous-espèces d'Eiders à duvet dans l'Est du Canada (Chapdelaine et al. 1986). La sous-espèce *sedentaria* est présente dans les secteurs de la baie James (Reed et al. 1996) et de la baie d'Hudson, la sous-espèce *borealis* sur les côtes du Labrador, du Nunavut et Nunavik (Reed et Erskine 1986) et la sous-espèce *dresseri* dans l'estuaire et le Golfe du Saint-Laurent, ainsi que dans les provinces Maritimes (Mawhinney et al. 1999) et le Maine. Des suivis réguliers de l'état des populations de la sous-espèce *dresseri* montrent que le nombre d'individus se reproduisant dans l'estuaire fluctue considérablement sans tendance apparente depuis plusieurs années malgré des efforts considérables pour améliorer les habitats de nidification,

notamment suite aux épidémies de peste aviaire (Groupe conjoint de travail sur la gestion de l'Eider à duvet 2004). La population des Eiders à duvet de l'estuaire du Saint-Laurent, vit dans des conditions très particulières de par l'importance de la présence humaine. Ce facteur « récent » est susceptible d'influencer la distribution des oiseaux par la pression des aménagements anthropiques le long du fleuve agissant sur les milieux naturels ou sur les oiseaux eux-mêmes.

La nidification de ce canard marin est observée principalement sur trois îles de l'estuaire (Bicquette, Blanche et Pommes) (Groupe conjoint de travail sur la gestion de l'Eider à duvet 2004). Ces habitats ont la particularité de présenter des caractéristiques de paysage très différentes d'une île à l'autre. Ainsi une île comme Bicquette présente un couvert forestier alors que l'île aux Pommes n'est recouverte que d'herbes rases. Cette plasticité dans le choix du site de nidification a été beaucoup étudiée et même si les conditions d'incubation sont différentes d'un site à l'autre notamment au niveau des pertes énergétiques de la femelle (Kilpi et Lindström 1997), les différents types d'habitats sont utilisés universellement dans l'estuaire du Saint-Laurent. Ceci est peut-être relié à l'attachement des femelles à leur île de nidification voire même à un secteur précis de celle-ci. La période de reproduction est la source d'importants stress énergétiques pour les femelles en nidification. Ainsi, d'importantes pertes de poids et des changements physiologiques majeurs sont observés durant l'incubation (Korschgen 1977). L'Eider à duvet est extrêmement grégaire durant la période de nidification et le nombre de nids peut atteindre 1500/ha sur certaines îles (Groupe conjoint de travail sur la gestion de l'Eider à duvet 2004). Ces caractéristiques ont permis à l'Eider à duvet de coloniser presque toutes les côtes maritimes nordiques de l'Est de l'Amérique du Nord mais elles constituent aussi des handicaps importants qui justifient que l'on protège ces populations. Par exemple, tout dérangement dans les colonies lors de la nidification peut provoquer l'abandon des nids par les femelles ou augmenter la prédation par les goélands qui cohabitent

habituellement avec les eiders dans cette région (Bolduc et Guillemette 2003). L'effectif de la population d'Eiders à duvet de l'estuaire du Saint-Laurent pourrait être fortement affecté par la perte ou la destruction d'une seule des trois principales îles de nidification. A cet effet, il faut mentionner que les îles importantes pour les eiders sont protégées par des organismes de conservation. Ainsi, ils en interdisent l'accès aux intrus et aménagent les habitats. Ces projets de conservation sont financés en partie grâce aux revenus générés par la cueillette du duvet qui s'effectue sur ces îles (Groupe conjoint de travail sur la gestion de l'Eider à duvet 2004).

Les sites d'élevage des jeunes se localisent le long des rives nord et sud du fleuve et ponctuellement autour de certaines îles. Les femelles accompagnées de leurs jeunes peuvent ainsi se déplacer, juste après l'éclosion, d'une dizaine de kilomètres (Gauthier et Bédard 1976) avant d'atteindre l'habitat favorable à la croissance des canetons. Ces derniers sont extrêmement vulnérables pendant la traversée depuis les îles de nidification, et la majorité de la prédation se déroule durant ces premiers jours de vie (Mawhinney et Diamond 1999). Une fois que les crèches ont atteint les sites d'élevage, elles restent fidèles au milieu durant l'ensemble de la période de croissance des jeunes limitant ainsi leurs déplacements. De même que pour les îles de nidification, les femelles reviennent souvent aux mêmes sites d'élevage d'une année à l'autre (Öst et Kilpi 2000). Les sites de mue de l'eider à duvet de l'estuaire ne sont pas connus précisément. Il semblerait que la majorité des adultes de cette population sélectionnerait des habitats de mue situés autour de l'île d'Anticosti (Savard, pers. comm). Cependant, un certain nombre d'eiders adultes sont annuellement aperçus en mue le long de la rive sud du fleuve. L'utilisation exclusive de sites d'élevage et de mue fixes et limités en superficie pose des problèmes dans un milieu fréquenté par l'homme. L'exploitation des ressources littorales (algues brunes, mollusques) par l'industrie et l'utilisation des zones littorales pour l'aquaculture, les activités récréo-touristiques comme le kayak de mer, les projets de mise en valeur touristique et les

usages résidentiels (villégiature) constituent d'authentiques menaces pour l'intégrité des habitats côtiers essentiels aux couvées d'eiders.

Depuis l'étude de Bédard et al. (1986) réalisée dans les années 70, aucune recherche n'a précisément caractérisé la répartition des eiders sur les sites d'élevage des jeunes malgré une évolution probable de l'écologie et des paysages des rives de l'estuaire du Saint-Laurent. Les sites de mue des adultes, quant à eux, ne sont pas définis précisément. Il est donc primordial d'étudier l'utilisation de ces milieux par les oiseaux afin d'obtenir de nouvelles connaissances et d'envisager des plans de conservation efficaces pour cette population. Plusieurs études ont montré que le dérangement humain a des effets sur le comportement des eiders (Hockin et al. 1992). Il provoque généralement une cessation des activités quotidiennes normales (*e.g.* alimentation, repos) par l'éloignement des individus, pouvant provoquer des carences au niveau énergétique ou favorisant l'attaque de prédateurs. Ces perturbations peuvent entraîner un abandon de certains secteurs côtiers anciennement peu dérangés et peu habités qui aujourd'hui sont soumis à un plus grand achalandage touristique. La sinuosité de la côte a été mentionnée comme pouvant procurer un abri aux jeunes eiders contre les mauvaises conditions météorologiques comme les vents et courants. Minot (1980) a décrit cette tendance dans la baie de Fundy, au Nouveau-Brunswick, à l'échelle du kilomètre. Bédard et al. (1986) n'ont pas trouvé d'influence de la sinuosité de la côte sur la répartition des canetons d'eider à duvet mais à l'échelle de l'estuaire du Saint-Laurent.

Objectifs et plan du mémoire

Dans ce mémoire, nous décrivons la distribution et le comportement de l'Eider à duvet durant deux périodes critiques de son cycle vital: l'élevage des jeunes et la mue des adultes.

Dans le premier chapitre, nous décrivons la répartition spatiale de l'Eider à duvet le long de la rive sud de l'estuaire du fleuve Saint-Laurent. Nous précisons

l'utilisation différentielle des sites d'élevage des jeunes et des sites de mue selon l'âge, le sexe et le statut des femelles (maternelles ou non maternelles) des oiseaux. Une caractérisation précise de la répartition de cet oiseau n'a pas été menée depuis les années 70 sur notre aire d'étude (Bédard et al. 1986) et nous avons besoin de données scientifiques récentes si nous voulons mener à bien un projet de suivi et de conservation de cette espèce. Grâce aux données de Bédard et al. (1986), nous effectuons une comparaison historique des densités d'Eider à duvet qui nous permet de visualiser l'évolution de la population depuis trente ans. Enfin, nous avons mis en relation la répartition spatiale des différentes catégories d'eiders avec des variables environnementales telles que la répartition des ressources alimentaires, le dérangement humain et la sinuosité de la côte.

Dans le deuxième chapitre, nous décrivons le budget d'activités diurnes de l'Eider à duvet selon leur âge, sexe et statut. Nous mettons l'emphase sur les liens entre les comportements et les besoins énergétiques de chacune des catégories d'oiseaux. Nous détaillons également la répartition spatiale au niveau local des eiders en relation avec la distance à la côte. Enfin, nous mettons en relation l'occurrence des comportements et des localisations en relation avec la distance à la côte avec des facteurs environnementaux tels que la répartition et l'abondance des ressources alimentaires, la fréquence du dérangement humain et la sinuosité de la côte.

CHAPITRE I

RÉPARTITION DE L'EIDER À DUVET PENDANT L'ÉLEVAGE DES JEUNES ET LA MUE DES ADULTES LE LONG DE L'ESTUAIRE DU FLEUVE SAINT-LAURENT, QUÉBEC, CANADA

Ce chapitre sera soumis pour publication sous le titre suivant:

Distribution of Common Eiders during the brood rearing and moulting periods in the St. Lawrence estuary (Quebec, Canada)

Hélène Diéval, Jean-François Giroux and Jean-Pierre L. Savard

Abstract

Common Eiders (*Somateria mollissima dresseri*) nest in colonies on islands of the St. Lawrence estuary in Quebec. After hatching, females must reach adequate habitats to rear their ducklings. Adult birds also undertake a moult in late summer but their distribution is not well known. The aim of our study was to determine the biotic and abiotic factors that influence the distribution of these birds during the brood-rearing and moulting periods. The number of Common Eiders was recorded bi-weekly by age and sex in 2003 and 2004 at 68 sites located along a 200-km stretch of the south shore of the St. Lawrence River. For adult females, we also noted whether they were accompanying young or not. We evaluated human disturbance, developed a sinuosity index to characterise shoreline protection, characterized the nature of the substrate, and estimated food abundance for a sub-sample of sites (n= 38). At the scale of the estuary, Common Eiders did not distribute randomly and used the same sites in both years. Females without ducklings and males were located farther east along the estuary, but their numbers were lower than expected based on the size of the breeding population, indicating that some birds undertake a moult migration. Broods preferred the westerly areas near the nesting islands. On a temporal scale, we observed that the densities of females without ducklings increased significantly during the summer as they moved eastward. Contrary to our expectations, the distribution of Common Eiders was not related to our indices of human disturbance and shoreline protection. Food abundance was the most

influential factor with each age and sex category distributed according to their preferred prey. In conclusion, we identify the best brood rearing and moulting sites for Common Eiders along the south shore of the St. Lawrence estuary based on biotic and abiotic factors. Very few of these sites are currently included within conservation areas and measures should be taken to ensure their integrity.

Introduction

Appropriate habitat selection is essential for birds to fulfill different needs during their annual cycle (Cody 1985). In Anatidae, the breeding and brood rearing periods influence reproductive output and the survival of ducklings and adult females (Nichols et al. 1982; Ringleman and Longcore 1982; Coulson 1984; Christensen 1999). Waterfowl species are known to suffer a lot of pressure during the breeding period from predation (Lokemoen et al. 1982; Nordström et al. 2002). Incubating females also suffer from weight loss (Korschgen 1977; Hohman 1986, Barzen and Serie 1990). For nidifugous Anatidae, the quality of brood-rearing habitat usually influences survival and size at fledging (Rhymer 1992; Pöysä and Virtanen 1994; Flint et al. 1998). Common Eider ducklings need a lot of energy intake to grow. They have a very low fledging rate (10-25%; Mendenhall and Milne 1985) mainly because of predation by gulls in the first weeks after hatching (Åhlund and Götmark 1989). Moreover, maternal females need to recover from their 26 days of fasting during incubation (Korschgen 1977). The selection of optimal brood-rearing habitats is therefore essential. Adult birds moult after the breeding season before migrating to their wintering areas. For most waterfowl species including Common Eiders, the selection of an optimal moulting habitat is essential to obtain the nutrients required for feather growth and to reduce their vulnerability to predators for example human disturbance when flightless.

Several environmental variables can explain how anatids select their habitat but the spatial distribution of feeding areas commonly defines their post-hatching dispersal (Pehrsson and Kenneth Nyström 1988; Cooch et al. 1993; Öst and Kilpi 2000). Hockin et al. (1992) found that human disturbance influenced most bird species in all parts of their life. Cornelius et al. (2000) showed that it has a global negative effect on bird abundance but that the summer period is the worst because of increased human occurrence at coastal sites. More precisely for Common Eiders, human disturbance may impact duckling survival during the brood-rearing period, by increasing gull predation (Åhlund and Götmark 1989; Keller 1991). For moulting birds, the sound of an engine or even an aeroplane passing overhead may generate high-energy demanding activities like diving or fleeing at the expense of growing new feathers (Frimer 1994). During brood rearing, Minot (1980) found that eiders selected more sheltered sites in the Grand Manan Archipelago when weather conditions were less favourable and susceptible to influence survival of young as observed in Scotland (Mendenhall and Milne 1985). However, Bédard et al. (1986) failed to find such influence of weather and shore protection on the distribution of eiders in the St. Lawrence estuary.

In this study, we focused on Common Eiders during the brood-rearing and moulting periods in the St. Lawrence River estuary in southern Quebec. Bédard et al. (1986) described the distribution of eiders in the seventies but the current distribution is unknown. Since then, recreational activities such as kayak excursions, watercraft

activities, and cottage construction have increased along the shores of the St. Lawrence River while few areas have been established as parks (e.g. Parc national du Bic). Our main objective was to determine the current spatial and temporal distribution of eiders along the south shore of the St. Lawrence River estuary and to identify the habitats used during the brood-rearing and moulting periods. We also aimed to characterize the influence of environmental factors including food abundance, human disturbance, and shoreline protection on habitat selection to better understand the mechanisms behind the distribution of Common Eiders.

Study area

Our study took place along a 200-km stretch between Notre-Dame-du-Portage (47°4'N, 69°3'W) and Matane (48°5'N, 67°3'W) on the south shore of the St. Lawrence River in Quebec, Canada (Fig 1.1). We divided the area into 68 zones according to landscape features (bay, islet, boulder, etc.) and shore accessibility for observers. In total, 157 km or 78% of the south shore was sampled. We combined these zones into four geographical areas depending on their proximity to important breeding colonies. We thus established the Blanche, Pommes, and Bicquette areas, which refer to the names of the main breeding colonies in each region and Matane where no major colony exists.

The St. Lawrence River estuary is characterised by semi diurnal tides of 5 - 6 m amplitude. The shores of the western portion of the area are mainly covered with mud whereas those of the eastern parts are dominated by rocks. *Fucus vesiculosus*

and *Ascophyllum nodosum* are the dominant algal species covering the shores (Centre Saint-Laurent, 1996).The main marine organisms consumed by Common Eiders are littorinids (*Littorina spp.*) distributed equally all along the study area and blue mussels (*Mytulis edulis*) and amphipods (*Gammarus spp.*) that are more abundant in the eastern parts (Cantin et al. 1974; Ardisson and Bourget 1992).

Methods

Bird surveys

Biweekly ground observations were conducted in 2003 (n=15) and 2004 (n=17) from the beginning of June to the end of August. We used a spotting scope (20-60x) to count each bird that could be identified with certainty. Adult birds were recorded by sex and we distinguished whether adult females were maternal or not. Non-tending females were non-maternal and consisted of failed breeders, females that abandoned their young or sub-adult females. Only females exhibiting "leading" behaviour (status "B" in Bédard and Munro 1977) were considered maternal. Ducklings were aged using criteria described by Gollop and Marshall (1954). The zones were visited at different times of the day throughout the summer but usually with the same tide condition. Some zones were more easily surveyed at high tide while others were more accessible at low tide. The same observer (HD) conducted all surveys in 2003 whereas two persons (HD and an assistant) were involved in 2004. Training sessions were conducted at the beginning of 2004 and on several occasions throughout the summer to ensure consistency in counting birds and aging ducklings between the two

observers. To standardize observations, we calculated densities of birds per kilometre of shore. The mean of all surveys for each observation zone for each category of birds was calculated to determine the use of a zone in a given year. Each zone was considered a sampling unit to compare the four areas. To establish the temporal distribution for each year, we calculated the mean of all surveys conducted in June (2003: N=5, 2004: N=7), July (2003: N=5, 2004: N=5), and August (2003: N=5, 2004: N=5) using the zones within each area as sampling units.

Human disturbance

Disturbance was defined as human activity that induced a visible change in the distribution or behaviour of birds. For each zone, presence or absence of humans on shore or on water was noted during the surveys. In 2004, we also characterized the potential intensity of human disturbance according to each person activity: low (when the person was immobile), moderate (when the person was moderately active like walking) and extreme (when the person was running, shouting, or moving towards the birds). When the disturbance was on water, similar criteria were used: low (immobile or anchored boat), moderate (slow-moving canoes or kayaks) and extreme (rapidly-moving kayaks, speedboats). An overall human disturbance index was developed using the first component of a principal component analysis on five variables: the frequency of human disturbance, the total number of humans/km, and the number of persons in passive, moderate and extreme activity /km. This first component explained 74% of the variation. In 2003, we simply calculated the

proportion of surveys with human presence for each zone.

Bio-physical characteristics

Transects perpendicular to the shore were established to characterize the intertidal area of 38 randomly chosen zones within the 68 observation zones. Number of plots per zone varied between 100 (zone < 40 ha of intertidal area) to 200 for larger ones. All transects were equidistant in each zone as well as the plots along each transect. Sampling plots had a radius of 30 cm (0.283 m^2). The nature of the substrate at the centre of each plot was classified as mud, sand, gravel, stone, rock, or boulder and then expressed as a percentage for the whole zone. These percentages were subsequently included into a principal component analysis and the first component, which explained 42% of the total variation, was used to characterize the substrate of the zone. Both the algal and mussel covers were recorded according to the following categories: 0 = absence, 1 = 1 - 25%, 2 = 26 - 50%, 3 = 51 - 75%, and 4 = > 76%. Littorinids and amphipods were recorded as present or absent in each plot and then expressed as a percentage for the zone.

Shoreline protection

A shoreline sinuosity index was calculated from digitized maps (1:50 000) using Arcview (Environmental Systems Research Institute) to characterize the potential protection of the shores for the birds against wind and currents. We divided the length of the straight distance between the two limits of each observation zone by the total length of the shoreline within the zone. A sinuosity index of 1 refers to a

straight shoreline while a bay or a sinuous shoreline results in an index < 1.

Statistical analyses

Spearman's Rho correlation coefficients were calculated on densities among the different categories of eiders using the 68 zones for each year as well as between years for each category. We used ANOVAs with Tukey tests to compare the temporal distribution of eiders among geographical areas and bird categories. We used data of Bédard et al. (1986, Fig. 1.1) obtained in 1972 at the same sites and same time of the year to detect changes in the spatial distribution of eiders compared to 30 years ago. Bédard et al. (1986) did not distinguish between maternal and non-maternal females in their paper, so we grouped these two categories for the analysis. For 1972, the mean number of birds in all zones of the study area was calculated (N=22) and compared with the mean for the 68 zones surveyed in 2003 and 2004. Their relative distribution was calculated by dividing the absolute number of birds observed each year by the proportion of eiders in each geographical area.

We used stepwise multiple regressions to identify which environmental factors explained the distribution of eiders in the 38 intensively studied zones. We included five variables: shoreline sinuosity, human disturbance index, blue mussel cover, and presence of littorinids and amphipods. Mussels, littorinids and amphipods variables were positively correlated (Spearman Rho's; $r = 0.6$, $P<0.001$). However, the nature of substrate and the algal cover were excluded due to colinearity with the presence of littorinids. Substrate and food availability were only measured in 2004

but we are confident that the same values could be used to explain the 2003 distribution of eiders. At the scale of the estuary, the substrate is unlikely to have changed between years. Moreover, Bayne (1964) and Armonies (1996) found that spats of young *Mytilus edulis* tended to settle on existing adult mussel beds year after year. Similarly, Saier (2000) and Dethier and Schoch (2005) found the same spatial distribution of littorinids in consecutive years. All analyses were made with JMP software and the angular transformation was applied to proportions (Zar 1996).

Results

There was a greater proportion of muddy shores in the western parts of the study area ($F_{3,37} = 9.3$, $P<0.0001$; Table 1.1) and more rocky shores in the east ($F_{3,37} = 3.0$, $P<0.05$). Shoreline sinuosity was similar in the four areas whereas human disturbance was greater in Matane and Bicquette than in Blanche ($F_{3,37} = 6.0$, $P<0.01$). Blue mussels and gammarids were more abundant in the east ($F_{3,37} = 13.6$, $P<0.0001$; $F_{3,37} = 8.2$, $P<0.001$, respectively).

Spatial relationships among eider categories

The distribution of eider categories in each zone showed little seasonal variation and was consistent during both years of the study. As expected, the density of maternal females was highly correlated with ducklings but not with adult males (Table 1.2). The distribution of females without ducklings was moderately correlated with the distribution of males and slightly with ducklings. There was a seasonal reduction in the strength of the relationships in the distribution of females with and without

ducklings (2003: $r_{June} = 0.48$, $P<0.001$; $r_{July} = 0.28$, $P<0.01$ and $r_{August} = 0.31$, $P<0.001$; 2004: $r_{June} = 0.53$, $P<0.001$; $r_{July} = 0.44$, $P<0.001$ and $r_{August} = 0.33$, $P<0.001$).

Spatial and temporal variation in eider distribution

There was considerable variation in bird density between and within years as well as among areas and eider categories (Fig. 1.2). Adults without ducklings were much more abundant than maternal females and ducklings in both 2003 and 2004 and were found principally in the eastern part of the study area with maximum numbers in August. Male densities in Matane were higher than in the other three areas (June 2003: $F_{3,67} = 4.9$, $P<0.01$; July 2003: $F_{3,67} = 4.9$, $P<0.01$; August 2003: $F_{3,67} = 3.6$, $P<0.02$; June 2004: $F_{3,67} = 24.0$, $P<0.001$; July 2004: $F_{3,67} = 10.0$, $P<0.001$, and August 2004: $F_{3,67} = 6.2$, $P<0.001$). There were more females without ducklings in Matane in August 2003 and 2004 than in the other regions (2003: $F_{3,67} = 3.8$, $P<0.02$; 2004: $F_{3,67} = 6.7$, $P<0.001$). Adults without ducklings showed little annual variation whereas the total number of maternal females and ducklings were lower in 2004 than 2003 ($F_{1,135} = 17.7$, $P<0.0001$) indicating decreased production during the second year of our study. Broods tended to move eastward in August with high numbers in June and July in the Blanche and Bicquette areas and a reduction in August ($F_{3,67} = 4.2$, $P<0.01$). Generally, their numbers were higher around the breeding regions compared to Matane.

Zone fidelity

Broods generally used the same sites in 2003 and 2004 within each geographical area except for ducklings in the Bicquette area (Table 1.3). There was a decrease in the strength of the relationship for females without ducklings from Blanche to Matane. This indicates a greater fidelity in the western portion of our study area. Male densities were correlated only for Bicquette and Matane, possibly reflecting the low numbers of males in the western areas.

Historical comparisons

There were about twice as many adult females in 1972 than during our study ($F_{2,162}$ = 7.76, P<0.0001) (Fig. 1.3). The relative distribution of females was constant in Blanche and Pommes throughout the three years with 8 and 11 individuals/km of shore, respectively, but twice the density in 1972 in Bicquette (32 individuals/km in 1972 vs. 16 in 2003-2004) and in Matane (53 individuals/km in 1972 vs.17 and 27 in 2003 and 2004, respectively). Following a similar pattern, the total number of ducklings was half the density in 2004 than in 1972 ($F_{2,162}$ = 11.5, P<0.0001; Fig. 1.3). Their relative distribution varied between areas and years with no apparent trend. The total number of males and their relative distribution among areas were constant during the three years surveyed.

Influence of environmental factors on eider density

The distribution of maternal females was positively correlated with the presence of littorinids and negatively with mussel cover in both 2003 and 2004 (Table 1.4).

Duckling numbers were mainly distributed according to littorinids while females without ducklings were distributed according to mussels in 2003 and gammarids in 2004. However, in 2003 non-tending females were distributed according to gammarid abundance in June (R^2=0.35, $F_{2,37}$=9.5, P<0.0005) and mussel cover in July (R^2=0.37, $F_{2,37}$=10.3, P<0.0003) and August (R^2=0.28, $F_{1,37}$=14.2, P<0.0006). No seasonal variation was observed for maternal females and their ducklings. In both years, male distribution was only influenced by blue mussel abundance and this was consistent throughout the summer months. Our indices of shoreline protection and human disturbance were not correlated with the distribution of eiders in the 38 zones studied.

Discussion

Seasonal distribution

Our analyses revealed similar distribution patterns for maternal females and ducklings, which was expected. In addition, maternal females were the most consistent with respect to the choice of brood-rearing sites year after year as previously reported by Munro and Bédard (1977). This philopatry is important considering the selection of appropriate habitats to rear ducklings and to recover from the stress of incubation.

After hatching, ducklings need energy and nutrients to complete their growth. It is thus advantageous for maternal females to select appropriate habitats near their original nesting island to minimize energy expenditure associated with movements

over water (Gauthier and Bédard 1976). During the first few days of rearing, however, mortality due to predation may be important, especially around colonies where gulls are nesting (Swennen 1989). This is the case on most islands of the St-Lawrence River where Great-Black-Backed Gulls (*Larus marinus*) and Herring Gulls (*Larus argentatus*) nest. Maternal females must balance the costs between moving sufficiently away from the islands to escape from gulls and find optimal brood-rearing sites while minimizing the travel distance for their young. In the St-Lawrence River estuary, most broods leave the islands right after hatching and distribute themselves along the mainland shores closest to the breeding islands (Gauthier and Bédard 1976). The difference in duckling distribution between the two years in some geographical areas was probably due to their reduced number in 2004 including many zones with no individual. There were about half as many ducklings in 2004 as in 2003 for all areas and we failed to observe broods in some zones where some had been recorded in 2003. Adverse weather conditions during the hatching peak in 2004 may have been responsible for the reduced production that year.

Kenneth Nyström et al. (1991) and Öst and Kilpi (2000) found that broods tended to distribute according to their preferred prey in the Baltic Sea. Maternal females used areas with an abundance of littorinids but with fewer mussels, thus selecting optimal habitats for their ducklings but less productive for themselves (Öst and Kilpi 1999). They may therefore have a less efficient energy intake than non-tending females that have the opportunity to move to areas where more appropriate

preys are available. In the St. Lawrence estuary, Cantin et al. (1974) observed that females without ducklings moved more "seawards" than maternal females, possibly to feed on mussels whereas maternal females fed in the intertidal zone on littorinids like their ducklings. They reported that littorinids had a lower flesh/shell ratio than mussels and that littorinids could be considered as a less appropriate food supply for females that are in poor body condition after incubation.

Gauthier and Bédard (1976) and Bédard et al. (1986) suggested that moulting sites for females were located in the Matane area. In our study, non-tending females also tended to locate in this region but we failed to find evidence of local philopatry in successive years, at least in terms of relative abundance. The number of non tending females varies annually depending on breeding success as well as on duckling survival and abandonment after hatching. The reduced production of young in 2004 implied a reduced number of females associated with broods and therefore a greater number of non-tending females in 2004 than in 2003. Moreover, Kilpi et al. (2001) found that individual females can switch from maternal to non-maternal behaviour according to their body condition. Thus, females without ducklings may not be the same individuals each year. This situation may add variation to the relative distribution of these females and could explain the low correlation coefficient for the density of non-tending females in the Matane area between 2003 and 2004.

Because we did not observe any immature males on the study area during both summers, it is unlikely that non-tending females could represent sub-adult birds.

Females observed without ducklings were thus failed-breeders or birds that had lost their ducklings after hatching through predation or brood amalgamation (Milne and Reed 1974; Mawhinney and Diamond 1999; Mawhinney et al. 1999). Most females observed in the study area must have invested some energy into breeding and were thus more likely to be in poor body condition. Like maternal females, non tending females need to recover some energy before undertaking their moult. The persistence of maternal behaviours (Schmutz et al. 1982) and poor body condition (Korschgen 1977; Kilpi and Lindström 1997) just after hatching may explain why these females tended to follow broods in June. They gradually moved eastward during the summer with increasing numbers in Matane in August. We can presume that once they have acquired some energy and their maternal behaviours have attenuated, females move eastward and aggregate to look for richer prey like blue mussels. This is confirmed by the temporal evolution that appeared in 2003 when the distribution of non-tending females switched from sites with high concentrations of gammarids in June to sites abounding with mussels in July and August. Gauthier and Bédard (1976) found that 93% of females tagged on the breeding islands were observed on the south shore of the St. Lawrence River. However, the number of caring and non-caring females observed along the south shore compared to the breeding population (ca. 30,000 breeding pairs (The Joint Working Group on the Management of the Common Eider 2004)) suggests that a portion of the adult females migrate just after the breeding period to moult elsewhere.

McKinney (1961) found that male eiders stay close to breeding islands until one week after nest initiation possibly trying to mate with late or failed breeding females. In the St. Lawrence River estuary, Bédard et al. (1986) observed that the number of males after the young had hatched around the breeding islands was not substantial. Our data also indicate that in June, the majority of males were already at moulting sites in the eastern part of the study area. Similar to non-tending females, the total number of males observed in our area was much lower than expected based on the breeding population (Giroux, Bédard, unpublished data). We suspected that a significant proportion of males migrate to moulting sites, possibly in the Gulf of St-Lawrence. Savard (unpubl. data) has noted large concentrations of moulting males around Anticosti Island and a few smaller ones along the north shore of the estuary.

Flint et al. (2000) described the fidelity of male Steller Eiders (*Polysticta stelleri*) to moulting sites in Alaska. This also seemed to be the case for male Common Eiders in the Matane area during the two summers of our study. Moreover, eider males distributed according to the abundance of blue mussels in the eastern part of the estuary during both years. Contrary to non-tending females that suffer energy depletion during the breeding season, males are not in energetic stress after the young hatched so they are able to move to optimal sites with mussel beds that are found on the rocky shores of the Matane area.

Human disturbance

Human disturbance and shoreline protection did not appear as important factors influencing the density of Common Eiders in the St. Lawrence estuary. Keller (1991), Åhlund and Götmark (1989), and Hamilton (2001) showed that human related disturbances affect duckling survival mainly by enhancing gull predation. In our study area, gull predation is significant on or near some islands where nesting eiders and gulls are sympatric and this problem is accentuated when human disturbance occurs (J-F Giroux, pers. obs.). Along the mainland shores located at some distance from the islands, predation on ducklings by gulls is rare because it appears more profitable for gulls to feed near the islands than to cross over to the mainland. During two years, we witnessed only one instance of predation by two Great Black-Backed Gulls on a 20-day old duckling. It is possible that the disturbance level recorded along the shores of the St-Lawrence River was not sufficient to adversely affect eider distribution. Nevertheless, Diéval et al. (in prep.) found that the activity of eiders was influenced by human disturbance.

Minot (1980) studied how broods were affected by exposure to different weather conditions along 6.8 km of shore that he divided into 10 sections. The sheltered sections were preferred by broods during some periods of the day depending on the tide. Bédard et al. (1986) did not find this influence in the St. Lawrence estuary. We think that shoreline protection has no global influence on eider distribution at the scale of our zones (ca. 2 km long) but it may at a more local

scale (~ 100 m), which we did not explore. Our results also suggest that eider density during the brood-rearing and moulting periods was probably influenced more by the spatial distribution of the food resources than by any other environmental variable.

Historical comparisons

Considering the annual variation observed during our study, caution is required to consider long term differences based on a limited number of years. For example, variation in the mean number of ducklings during the three years could be caused by interannual differences in predation rate and/or weather conditions during hatching (Mendenhall and Milne 1985). On the other hand, reduction in the number of adult females by more than a half since the seventies is worth mentioning. Adult Common Eiders generally have a high survival rate (ca. 85% (Krementz et al. 1996)) and a long-life expectancy (ca. 21 years (Coulson 1984)). We suggest that the decrease of adult females may be due to avian cholera outbreaks that occurred in the mid-eighties and in 2002 on most of the breeding islands of the St. Lawrence estuary (The Joint Working Group on the Management of the Common Eider 2004). It was estimated that 20% of nesting females were killed in 2002 (Giroux et al. unpubl data). The decline was more pronounced in the Bicquette area where the largest breeding colony (ca. 11,000 pairs) is located and in the Matane area used by non- or failed breeders.

We identify the main brood-rearing and moulting sites of Common Eiders along the south shore of the St. Lawrence River. Food abundance appears to be the most important characteristic to predict the presence of eiders. There is growing pressure to exploit these intertidal habitats for aquaculture including mussel farming or algae harvesting that may lead to changes in food distribution or abundance. Most nesting islands have been secured and protected but conservation of the integrity of feeding habitats is required to ensure appropriate management. Our study provides useful information to identify areas in the St. Lawrence estuary that should receive some form of protection.

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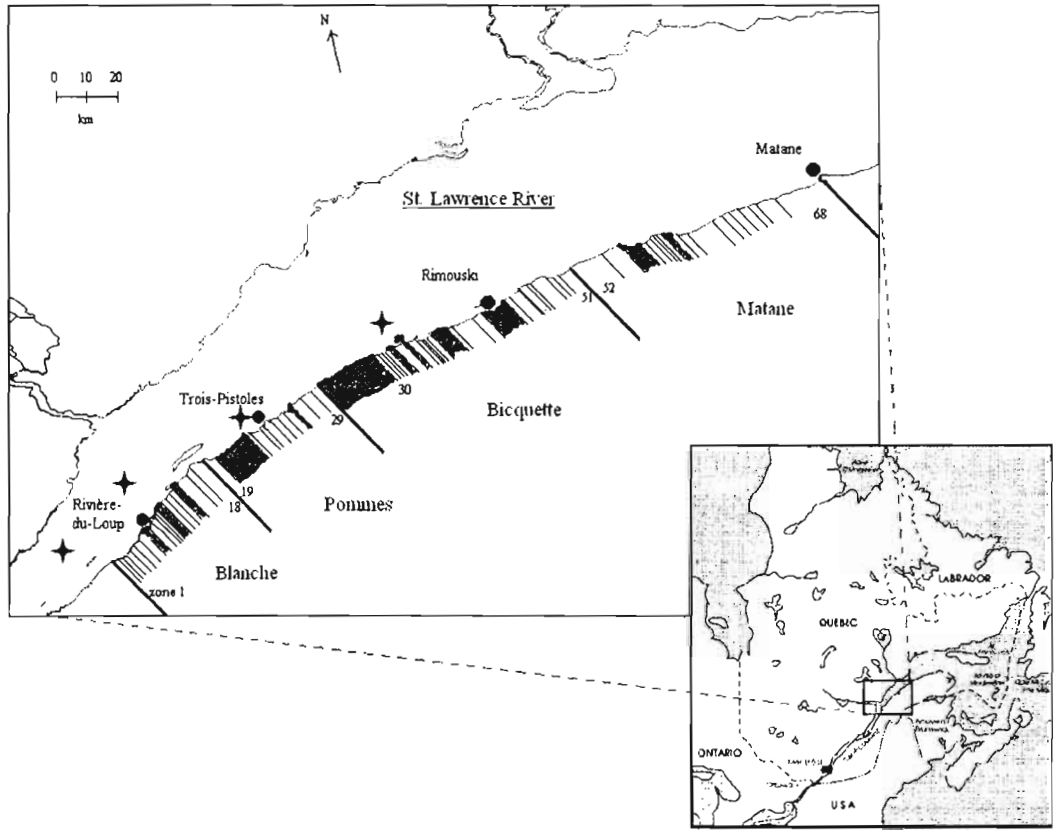

Fig. 1.1: Study area on the south shore of the St. Lawrence River, Quebec. The grey lines perpendicular to shore correspond to the 68 observation zones with identification numbers for the first and last of each region delineated by the bold lines. Dark grey areas were not sampled. The four stars correspond to main breeding islands (in number of nests) in the St. Lawrence estuary with île aux Fraises in the western part.

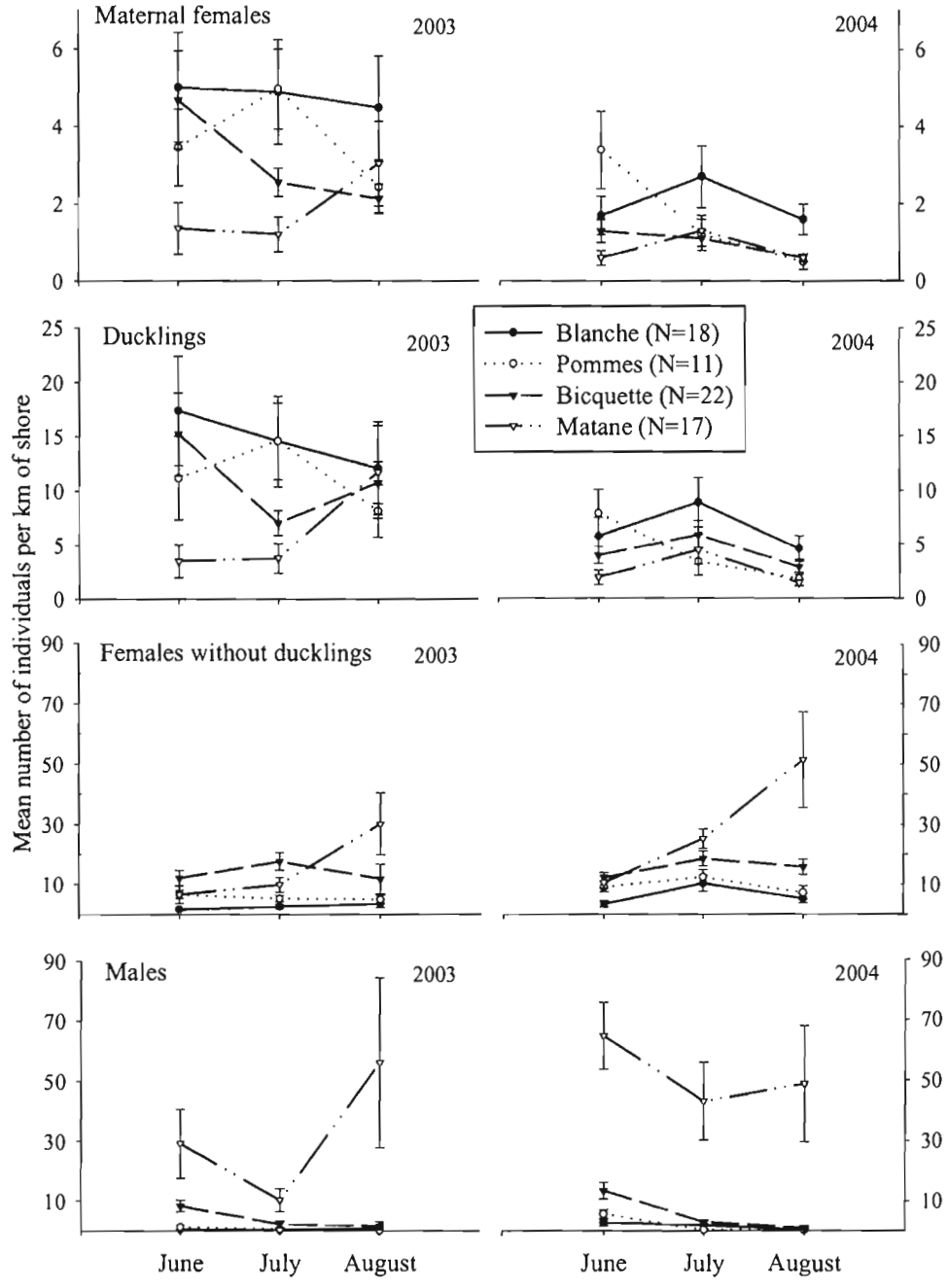

Fig. 1.2: Densities of Common Eiders throughout summer in 2003 and 2004 in the St. Lawrence estuary, Quebec. Data are presented as means ± SE.

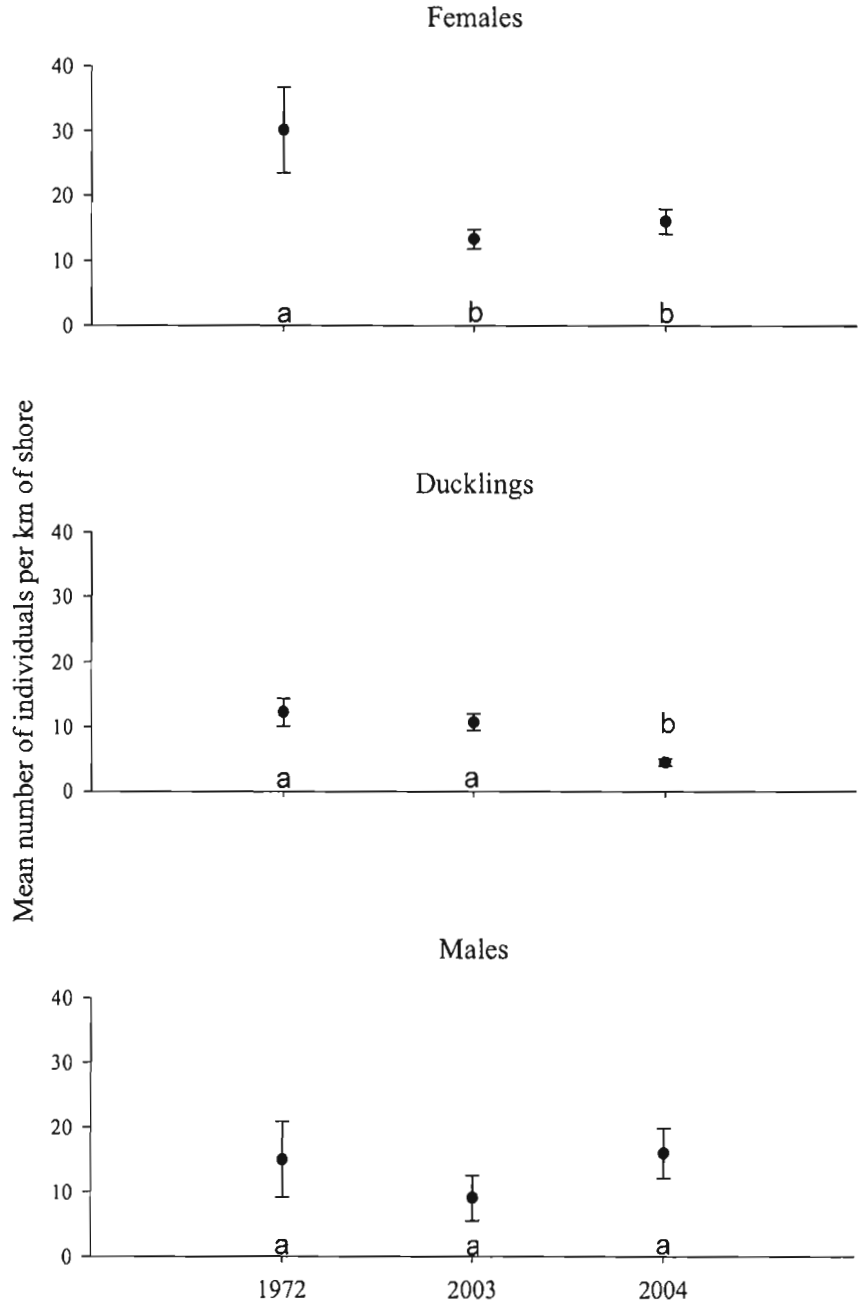

Fig. 1.3: Historical comparison of the densities of Common Eiders in the St. Lawrence estuary, Quebec. "Females" include maternal and non-tending females. Data for 1972 are from Bédard et al. (1986, Fig. 1).

Table 1.1: Bio-physical characteristics of the shores used by Common eiders during brood-rearing and moulting along the St. Lawrence estuary. Note: Means expressed ± 1 SE and sample sizes in parentheses. Means followed by the same letters are not significantly different (Tukey-Kramer tests, $p > 0.05$)

	Geographical areas				
Parameters	Blanche (N)	Pommes (N)	Bicquette (N)	Matane (N)	Study area (N)
Shore length (km)	1.7 ± 0.2 (18)	2.1 ± 0.2 (11)	2.3 ± 0.3 (22)	3.1 ± 0.7 (17)	2.3 ± 0.2 (68)
Shoreline sinuosity	0.8 ± 0.07 (10) ^{A}	0.9 ± 0.03 (5) ^{A}	0.7 ± 0.07 (13) ^{A}	0.8 ± 0.05 (10) ^{A}	0.8 ± 0.03 (38)
Frequency of Human-Disturbance	14.7 ± 6.6 (10) ^{A}	40.0 ± 9.3 (5) ^{AB}	51.1 ± 5.8 (13) ^{B}	41.1 ± 6.6 (10) ^{B}	37.4 ± 4 (38)
Total number of humans/km	5.5 ± 39.5 (10) ^{A}	25.4 ± 55.8 (5) ^{A}	90.5 ± 34.6 (13) ^{A}	11.5 ± 39.5 (10) ^{A}	38.7 ± 20.4 (38)
Number of passive persons/km	0.6 ± 22.9 (10) ^{A}	2.8 ± 32.4 (5) ^{A}	42.1 ± 20.1 (13) ^{A}	2.2 ± 22.9 (10) ^{A}	15.5 ± 11.7 (38)
Number of moderate persons/km	2.5 ± 12.7 (10) ^{A}	18.3 ± 17.9 (5) ^{A}	37.4 ± 11.1 (13) ^{A}	7.1 ± 12.6 (10) ^{A}	17.7 ± 6.6 (38)
Number of high activity persons/km	2.3 ± 4.7 (10) ^{A}	4.2 ± 6.4 (5) ^{A}	10.9 ± 4.0 (13) ^{A}	2.3 ± 4.7 (10) ^{A}	5.5 ± 2.3 (38)
Nature of Substrate (%): mud	44.0 ± 6.2 (10) ^{A}	7.7 ± 8.7 (5) ^{B}	8.5 ± 5.4 (13) ^{B}	2.9 ± 6.2 (10) ^{B}	16.3 ± 4.1 (38)
Sand	15.9 ± 5.5 (10) ^{A}	27.9 ± 7.8 (5) ^{A}	28.2 ± 4.8 (13) ^{A}	14.4 ± 5.5 (10) ^{A}	21.3 ± 2.9 (38)
Gravel	16.2 ± 3.3 (10) ^{A}	23.7 ± 4.7 (5) ^{A}	24.2 ± 2.9 (13) ^{A}	29.4 ± 3.4 (10) ^{A}	23.4 ± 1.8 (38)
Stone	13.0 ± 2.8 (10) ^{A}	25.1 ± 4.0 (5) ^{A}	17.0 ± 2.5 (13) ^{A}	19.7 ± 2.8 (10) ^{A}	17.7 ± 1.5 (38)
Rock	7.1 ± 4.8 (10) ^{A}	10.5 ± 6.8 (5) ^{AB}	17.1 ± 4.2 (13) ^{AB}	26.7 ± 4.8 (10) ^{B}	16.1 ± 2.6 (38)
Boulder	3.8 ± 1.8 (10) ^{A}	4.9 ± 2.5 (5) ^{A}	3.1 ± 1.6 (13) ^{A}	6.8 ± 1.8 (10) ^{A}	4.5 ± 0.9 (38)
Algal cover (%)	14.4 ± 2.8 (10) ^{A}	23.2 ± 4.0 (5) ^{A}	15.5 ± 2.5 (13) ^{A}	18.1 ± 2.8 (10) ^{A}	16.9 ± 1.5 (38)
Blue mussel cover (%)	0.6 ± 1.7 (10) ^{A}	9.8 ± 2.4 (5) ^{B}	10.9 ± 1.5 (13) ^{B}	15.9 ± 1.7 (10) ^{B}	9.4 ± 1.3 (38)
Percentage of plots with littorinids	49.5 ± 7.6 (10) ^{A}	74.8 ± 5.2 (5) ^{A}	60.3 ± 7.7 (13) ^{A}	70.0 ± 2.2 (10) ^{A}	61.9 ± 3.6 (38)
Percentage of plots with amphipods	24.6 ± 3.7 (10) ^{A}	51.8 ± 5.3 (5) ^{B}	38.8 ± 3.3 (13) ^{B}	46.5 ± 3.7 (10) ^{B}	38.8 ± 2.4 (38)

Table 1.2: Spearman correlation coefficients between common eider categories along the St. Lawrence estuary, Quebec, 2003-2004.

Comparison	2003	2004
Maternal females vs. Ducklings	0.94 ***	0.94 ***
Maternal females vs. Females without ducklings	0.20	0.37 **
Maternal females vs. Males	0.22	0.06
Females without ducklings vs. Ducklings	0.28 *	0.34 **
Females without ducklings vs. Males	0.65 ***	0.72 ***
Males vs. Ducklings	0.02	0.005

* $P<0.05$, ** $P<0.01$ and *** $P<0.001$; df = 66

Table 1.3: Spearman correlation coefficients between the densities of Common Eiders in the St. Lawrence estuary in 2003 and 2004

Geographical area	Tending females	Ducklings	Non-tending females	Males
Blanche (N=18)	0.94 ***	0.86 ***	0.84 ***	0.29 n.s.
Pommes (N=11)	0.64 *	0.62 *	0.62 *	0.48 n.s.
Bicquette (N=22)	0.66 ***	0.38 n.s.	0.41 *	0.41 *
Matane (N=17)	0.74 ***	0.67 **	0.35 n.s.	0.45 *

* P<0.05, ** P<0.01 and *** P<0.001; df=66

Table 1.4: Environmental variables that explain the densities of different categories of Common Eiders in 2003 and 2004, along the St. Lawrence estuary, Quebec (N = 38 zones). Regression coefficients (±SE) are presented for each significant variable entered in to the model.

	2003				2004			
Category	Statistical model	R^2	F	P	Statistical model	R^2	F	P
Maternal females	- 1.9 mussels (±0.79)* + 2.0 littorinids (± 0.53)***	0.28	7.1	<0.002	- 1.22 mussels (±0.55)* + 1.51 littorinids (± 0.37)***	0.31	8.1	<0.001
Ducklings	1.69 littorinids (± 0.6)*	0.16	7.1	<0.01	- 1.84 mussels (± 0.87)* + 2.50 littorinids (± 0.58)***	0.34	9.23	<0.001
Females without ducklings	3.70 mussels (± 0.77)***	0.38	22.9	<.0001	3.91 gammarids (± 0.75)***	0.42	26.8	<.0001
Males	4.37 mussels (± 0.9)***	0.39	23.3	<.0001	3.84 mussels (± 1.04)***	0.27	13.59	<0.001

* P<0.05, ** P<0.01 and *** P<0.001.

CHAPITRE II

COMPORTEMENTS DE L'EIDER A DUVET DURANT L'ELEVAGE DES JEUNES ET LA MUE DES ADULTES LE LONG DE L'ESTUAIRE DU SAINT-LAURENT, QUÉBEC, CANADA

Ce chapitre sera soumis pour publication sous le titre suivant :

Activity of Common Eiders during brood-rearing and moulting in the St. Lawrence River estuary

Hélène Diéval, Jean-François Giroux and Jean-Pierre L. Savard.

Abstract

There are several breeding colonies of Common Eider (*Somateria mollissima dresseri*) on islands in the Saint-Lawrence River estuary. After hatching, broods are taken to the mainland shores for rearing while adult males and non maternal females depart for their moulting sites. The aim of our study was to characterize the activity of these birds and their location across a water depth gradient along the shores, and secondly, to estimate the influence of environmental factors on this utilization. In 2004, we recorded the number and activity of Common Eiders according to age and sex and their distance from shore. For adult females, we also noted whether they were accompanied by young. Surveys were conducted bi-weekly at 68 sites located along a 200-km stretch of the south shore of the St. Lawrence River. We evaluated human disturbance, developed a sinuosity index to evaluate shoreline protection, characterized the nature of the substrate, and estimated food abundance. Broods (maternal females and ducklings) spent around 70% of their time foraging in the inter-tidal zone throughout summer. In contrast, males spent around 80% of their time loafing in the intermediate and offshore zones. Non-maternal females behaved like broods in June and July, mainly foraging in the inter-tidal zone and more like males in August, mainly loafing in the intermediate zone. Broods and non-tending females were distributed according to food resources in sheltered habitats in June and July and human disturbance negatively influenced the loafing activities of all adults. Activities of Common Eiders were sensitive to distribution of food resources,

shoreline sinuosity and human activities influenced by the summer month and the age/sex/parental category. Very few of the preferred sites, selected during summer, are currently included within conservation areas and measures should be taken to ensure their protection.

Introduction

Summer is particularly important for waterfowl as they reproduce and moult during that period. In addition to the selection of a suitable habitat to fulfil energetic needs (Cody 1985), migratory birds should adapt their behaviour to the environment to improve their fitness. For example, they should be foraging where and when their main prey is most available or loafing where and when they are less susceptible to being disturbed. During critical periods such as brood-rearing or moulting, energy expenditures must be well balanced to avoid any loss that may decrease survival. Therefore, selection of an optimal habitat is fundamental but adopting appropriate behaviours associated with each environment is equally important. Physical factors such as human disturbance may alter behaviour (Hockin et al. 1992). For example, Bélanger and Bédard (1990) reported that human activities near bird sanctuaries (e.g. hunting, aircraft flights) reduced the diurnal feeding bouts of snow geese and forced them to feed at night. In a situation of energetic stress that requires energy intake, this delay could have negative effects. Minot (1980) also reported that eider broods changed their feeding behaviour in the Grand Manan Archipelago according to the protection of the shore against winds and currents.

Many studies have illustrated the plasticity of behaviours that allow a better balance between energy expenditure and energetic gains for Common Eiders throughout their annual cycle. In summer, moulting adults spent most of their time loafing during the day (Frimer 1995) whereas broods foraged more (Minot 1980).

Yet, Nilsson (1970), Campbell (1978), and Guillemette (1998) found that eiders are mainly diurnal throughout the year. Normally, they move from resting to foraging areas just before dawn and return to resting areas at dusk. However, Guillemette (1998) suspected that digestion constraints force some Common Eiders to feed at night because of the high proportion of ingested shells associated with the consumption of Blue Mussels (*Mytilus edulis*) in winter. Campbell (1978) found that adult Common Eiders in Scotland used different feeding techniques (dabbling, diving, and raft-feeding) to access blue mussel beds according to the tidal cycle. In the Grand Manan Archipelago (N. B., Canada), broods foraged mainly at rising and high tide when littorinids, their preferred preys, are available (Minot 1980).

Diéval et al (2006) have shown that broods of Common Eiders used the western part of the St. Lawrence River estuary while post-breeding and moulting birds used the eastern portion. Behaviour of these birds and use of space along the shoreline are currently unknown. The three main objectives of our study were to: 1) establish activity budgets of Common Eiders during the summer according to their age, sex, and parental status (tending or non-tending females); 2) determine eider distribution across a water depth gradient along the shores within brood-rearing and moulting areas; and 3) determine the influence of environmental factors such as food resources, human disturbance, and shoreline protection on the time spent in various activities by eiders throughout the summer.

Study area

Our study took place along a 200-km stretch of the south shore of the St. Lawrence River between Notre-Dame-du-Portage (47°4'N, 69°3'W) and Matane (48°5'N, 67°3'W) in southern Quebec. We divided the area into 68 zones according to landscape features (bay, islet, rock, etc.) and shore accessibility for observers. In total, 157 km or 78% of the area was sampled (Diéval et al. 2006).

The shores of the St. Lawrence River are characterised by semi diurnal tides with up to 5-6 m of amplitude. *Fucus vesiculosus* and *Ascophyllum nodosum* are the dominant algal species covering the shores (Centre Saint-Laurent, 1996).The main marine organisms consumed by Common Eiders were littorinids (*Littorina spp.*) distributed equally all along the study area and Blue Mussels and amphipods (*Gammarus spp.*) that were more abundant in the eastern part (Ardisson and Bourget 1992). A more detailed description of the area can be found in Diéval et al. (2006).

Methods

Bird surveys

Ground observations were conducted biweekly in 2004 (N=17) from early June to late August. We used a spotting scope (20-60x) to count each bird that could be identified with certainty. Adult birds were sexed and we distinguished whether females were maternal or not. Non-tending females were non-maternal and consisted of failed breeders, females that abandoned their young or sub-adult birds. Only females with the "leading" behaviour (status "B" in Bédard and Munro 1977) were

considered maternal. Ducklings were aged using criteria described by Gollop and Marshall (1954). The zones were visited at different times of the day throughout the summer but usually with the same tide condition. Some zones were more easily surveyed at high tide and others at low tide. Two persons (HD and an assistant) conducted all the surveys. Training sessions were conducted at the beginning of the season and at several occasions throughout the summer to ensure consistency in counting birds and aging ducklings between the two observers.

We divided bird activities into: feeding (diving or consuming prey at the surface), loafing (resting on water, on a rock, or on shore) and locomotion (swimming on water or walking on shore). At the same time, we noted the bird location across a water depth gradient along the shore: 1) the terrestrial area (birds out of the water); 2) the intertidal area; 3) the intermediate area located between the edge of low tide and 50 m offshore; and 4) the offshore area. For groups of less than 200 individuals, we recorded activity and location for each bird. For larger groups, we randomly sampled 200 birds by scanning the flock along virtual lines perpendicular to the shore across the whole flock. The observed proportions were applied to the entire group. We calculated the percentage of birds in each activity and location on the total number of birds present in each observation zone for each survey. We then calculated the mean proportion for each activity or location for all surveys in June (N=7), July (N=5) and August (N=5). Finally, we calculated the

mean proportion of eiders in each activity and location for the 17 surveys conducted during the entire season to test the influence of environmental factors.

Human disturbance

Disturbance was defined as human activity that induced a visible change in the distribution or behaviour of birds. For each zone, presence or absence of humans on shore or on water was noted during the surveys. We also quantified human disturbance based on its activity: low (when immobile), moderate (when engaged in moderate activity like walking) and high (when running, shouting or moving towards the eiders). Similar criteria were used for disturbances on the water: low (immobile or anchored boat), moderate (canoes), and high (kayaks, speedboats). An overall human disturbance index was developed using the first component of a principal component analysis on five variables of the frequency and intensity of disturbance. This first component explained 74% of the variation (Diéval et al. 2006).

Bio-physical characteristics

Transects perpendicular to shore were established to characterize the intertidal area in 38 randomly chosen zones within the 68 observation sites. Number of plots per zone varied between 100 (zone < 40 ha of intertidal area) to 200 for larger ones. All transects were equidistant in each zone as well as the plots along transects. Sampling plots had a diameter of 60 cm (0.28 m^2). The nature of the substrate at the centre of each plot was classified as mud, sand, gravel, stone, rock or boulder. Both the algal and mussel cover were recorded as: 0 = absence, 1 = 1 - 25%, 2 = 26 - 50%, 3 = 51 -

75%, and 4 = > 76%. Littorinids and Gammarus spp. were recorded as present or absent in each plot. The substrate was characterized by the first component of a principal component analysis on the six different categories mentioned earlier, which explained 42% of the total variation. A shoreline sinuosity index was calculated from digitised maps (1:50 000) using Arcview (Environmental Systems Research Institute) to evaluate shore protection. We divided the length of the straight distance between the edges of the observation zones by the total length of the shore line. A straight shoreline yields an index of 1 while a sinuous shoreline will tend towards 0.

Statistical analyses

Angular transformations were applied to all proportions including activity, locations, and food resources (Zar 1996). To take the number of eiders into account in the observation zones, we used the inverse variance as a weighting factor according to the following formula (Kleinbaum et al. 1988):

$$w = 1 / \text{var (prop)}$$

w: weight

var (prop): variance of proportion = p * q / N

We used ANOVAs to compare the weighted proportions between summer months and eider categories. Stepwise multiple regressions were used to identify which environmental factors explained the occurrence of the main activities in the 38 observation zones studied intensively. We included five variables as environmental factors: shoreline sinuosity, human disturbance index, blue mussel cover, and

presence of littorinids and amphipods. Mussels, littorinids and amphipods variables were positively correlated (Spearman Rho's; $r = 0.6$, $P<0.001$). Nature of substrate and algal cover were not used due to their colinearity with the "littorinids" variable. All analyses were conducted using JMP software.

Results

Activity of Common Eiders

Eider activity varied among bird categories and summer months (Fig. 2.1). Maternal females and ducklings foraged at the same intensity throughout the summer (n.s.). Broods decreased their foraging activities slightly from June to August (maternal females: $F_{2;121} = 10.1$, $P<0.0001$; ducklings: $F_{2;121} = 9.9$, $P<0.0001$) but still foraged more than non-tending females and males throughout the summer (June: $F_{3;199} = 149.7$, $P<0.0001$; July: $F_{3;173} = 64.7$, $P < 0.0001$; August: $F_{2;136} = 33.6$, $P<0.0001$). Non-tending females decreased their foraging activities from 35% in June to only 8% in August ($F_{2;173} = 37.5$, $P<0.0001$) and conversely increased their time loafing from 47% in June to 78% in August ($F_{2;178} = 37.3$, $P<0.0001$). Overall, non-tending females and males spent more time loafing than broods throughout the summer (June: $F_{3;190} = 446.4$, $P<0.0001$; July: $F_{3;176} = 78.4$, $P<0.0001$; August: $F_{3;162} = 64.4$, $P<0.0001$). In August, non-tending females and males spent the same proportion of time in foraging and loafing activities (n.s.). Finally, locomotion (mostly swimming), was higher for ducklings but did not exceed 30% (June: $F_{3;189} = 10.2$, $P<0.0001$; July: $F_{3;190} = 11.9$, $P<0.0001$; August: $F_{3;142} = 9.3$, $P<0.0001$).

Distribution across the water depth gradient

We observed differences in eider location across the water depth gradient according to their status but not among summer months (Fig. 2.2). Maternal females and ducklings were located in the same areas all summer (n.s.) and spent 70% of their time in the intertidal zone. This was far more important than for non-tending females and males (June: $F_{3;190}$ 213.3, $P<0.0001$; July: $F_{3;179} = 139.7$, $P<0.0001$; August: $F_{3;137} = 59.6$, $P<0.0001$). Non-tending females decreased their use of the intertidal zone from 42% in June to 16% in August ($F_{2;176} = 36.6$, $P<0.0001$). Males shifted from the intermediate and terrestrial zones in June and July (approximately 50% of the observations) to the offshore zone in August (also around 50%) ($F_{2;86} = 33.8$, $P<0.0001$).

Human disturbance

The frequency of human disturbances increased from less than 20% in June to 46 and 50% in July and August, respectively ($F_{2;15} = 24.7$, $P<0.0001$). Disturbances on shore were three times more frequent than on water ($F_{1;16} = 64.7$, $P<0.0001$).

Influence of environmental factors on eider activity

Foraging activities of tending and non-tending females increased with human disturbance and the abundance of small food items (littorinids but mainly gammarids) (Table 2.1). The negative effect of mussel abundance for maternal females possibly reflects their use of sites devoid of this prey and colonised by prey preferred by juveniles. In June, broods and non-tending females fed in more

sheltered habitats. No model was established for males due to the low proportion of time spent foraging throughout the summer.

For loafing activities, human disturbance was the only variable that was repeatedly selected for each category of adults. Both males and females seemed to favour quiet habitats but females were also observed loafing on sites with abundant food resources.

Discussion

In the St. Lawrence estuary, broods (maternal females and ducklings) spent nearly 70% of their time foraging. Minot (1980) found similar results in the Grand Manan Archipelago in New-Brunswick. Ducklings of nidifugous species require energy and nutrients to complete their growth and therefore spend a majority of time feeding. Common Eider females fast during egg-laying and incubation, which lasts on average 26 days and results in a 50% loss of body mass (Cantin et al. 1974 and Korschgen 1977). This explains why maternal females need to forage to such an extent during the rearing period. The diet of tending females is mainly composed of littorinids in July-August and gammarids in August-September (Cantin et al. 1974). Therefore, it is not surprising that tending females behaved like ducklings throughout summer. Broods in the St. Lawrence estuary actually spent around 70% of their time in the intertidal zone as in the Bay of Fundy (Minot 1980). This matches the preferred distribution of their prey as littorinids are mainly concentrated in the

rockweed habitat along a vertical gradient within the intertidal zone (Gendron 1977, Saier 2000).

The time spent foraging by tending females was positively influenced by both human disturbance and the presence of gammarids and negatively by mussel abundance. Broods also spent more time foraging along the most sinuous and thus more protected habitats, which has also been observed in the Bay of Fundy by Minot (1980). This corroborates the idea that maternal females select habitats more suitable for their ducklings than for themselves. Öst and Kilpi (1999) and Diéval et al. (2006) found that maternal females were found in zones with an abundance of littorinids and gammarids. This should be beneficial for duckling growth and to improve their own body condition. Human disturbance can have negative effects on birds, especially during stressful periods like the nesting season or the rearing of ducklings (Hockin et al. 1992). Maternal females are affected by increasing their time foraging, yet, their energy intake may decrease. In fact, high levels of human disturbance can lead to an increase of energy expenditure by repetitive unsuccessful dives altered by over-vigilance behaviours.

The time budget of non-tending females was intermediate between that of maternal females and males. Non-tending females spent more time foraging in June and more time loafing in August. We also found that their foraging activities were negatively influenced by mussel abundance and positively by human disturbance and littorinids. This shows that, in June and July, non-maternal females tended to feed

preferentially in sheltered sites with abundant littorinids and few mussels, a behaviour normally associated with broods at the beginning of the brood-rearing period. In the same way, their increased loafing activities in August coincided with the utilization of quiet sites with abundant mussels, more energetically adapted to adult eiders. Schmutz et al. (1982) found that non-tending females present in brood foraging sites along the shores of Hudson Bay were both from the breeding and non-breeding cohorts. Our results illustrate the change in behaviour of failed-breeding females recovering from a stressful nesting period before their late summer moult. Bustnes (1996) concluded that the caring status of females did not influence their location or feeding behaviour from mid-June to late July in Norway. In the St. Lawrence River estuary, non-tending females shared the same activities and were located in the same intertidal zones as broods in June and July but behaved like adult males in August. Presumably, this is influenced by a lowering of their maternal behaviour and improvement of their body condition as summer progresses. Adult females that failed early or did not breed and thus did not suffer the energetic stress of incubation, may behave like males throughout the summer.

Eiders spent less time loafing in zones with greater human disturbance. Energy expenditure during moult must be limited to facilitate the growth of new feathers. Decrease in time spent loafing means an increase in more energetic activities and thus, a decrease in energy available for moult. Delay in moult may postpone migration and/or result in fewer fat reserves for wintering birds. Moreover,

the greater occurrence of non-tending females in areas with low human disturbance and abundant food resources suggests that they seek to minimise movements between loafing and feeding sites, confirming the low-cost activity strategy.

The behaviour of males was consistent throughout the summer as they spent around 80% of their time loafing. During the breeding season, they are less stressed energetically than females. Males concentrate at moulting sites in August where they stay well after their wing moult is completed. Adams et al. (2000) and Frimer (1995) found that Harlequin Ducks (*Histrionicus histrionicus*), King (*Somateria spectabilis*) and Common Eiders spent about 10% of their time foraging during moult. Basically, they are able to direct all their daily energy into feather production by spending most of their time loafing decreasing their energy demanding foraging activities. Peterson (1981) suggested that, in addition to increasing low cost activities, Steller Eiders (*Polysticta stelleri*) selected more energy profitable prey like blue mussels instead of gammarids. This suggests that the moulting period does not seem to be particularly stressful for males.

Frimer (1995) and Cantin et al. (1974) observed Common Eider males in the infralittoral zone diving to depths up to 15 m. Our results corroborate this, as males occurred in the intermediate and offshore zones most of the time. On the south shore of the St. Lawrence estuary, the limit of our observation capabilities generally did not represent depths greater than 10 m based on bathymetric maps. Eider plumage quality deteriorates in July during body moult, causing a possible increase in energy

expenditure related to thermoregulation when birds are in contact with water (Adams et al. 2000). That is likely why they spend longer time on shore where ambient temperature in July is higher than in June or August. In August, when a majority of males were flightless, they were found offshore. Frimer (1994) described male King Eiders that ceased feeding and began to gather and swim offshore when they heard the distant sound of an engine or at the sight of a boat approaching. When flightless, Common Eider males may avoid going on shore because of the higher risk of being disturbed as shown by our results. This corroborates the idea that moulting eiders select sites that offer safe loafing areas (Campbell and Milne 1983, Frimer 1994).

This study confirms that each category of Common Eiders behaves according to its energetic needs during summer. Broods spent a majority of their time foraging in the intertidal zone of sheltered areas with abundant gammarids throughout summer. Management plans should recognize these needs and preferences. Males loafed preferentially offshore in undisturbed areas and spent little time feeding during the day. Conversely, non-tending females showed both the characteristics of broods and males surely as a result on their breeding status. Diéval et al. (2006) found that Common Eiders in the St. Lawrence estuary selected their brood-rearing and moulting habitats according to food resources and that human disturbance or shoreline protection did not have a recognizable effect. We found that Common Eiders adapted themselves according to food resources and physical factors like

human disturbance and shoreline protection. Even if habitat selection is influenced by specific factors, behaviour and use of the shores may be influenced by others. Therefore, it is important to identify all the elements that may influence the characteristics of a population before elaborating complex management plans. Otherwise, conservation actions may not achieve their original goal.

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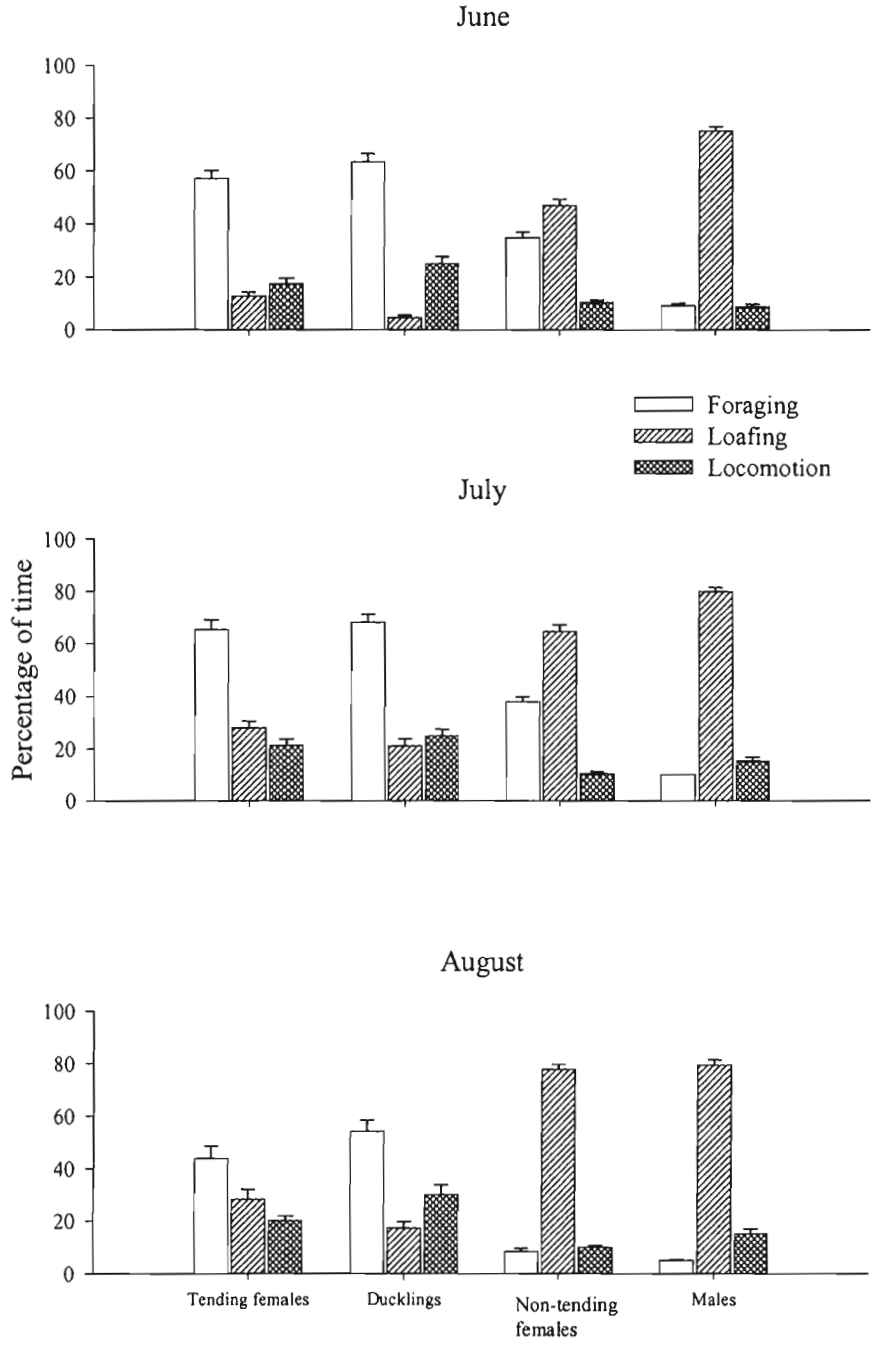

Fig. 2.1: Diurnal activities of four categories of Common Eiders from June to August 2004 in the St. Lawrence estuary, Quebec, Canada. Sample size varied between 38 and 67 zones with at least one observation of eiders during each period.

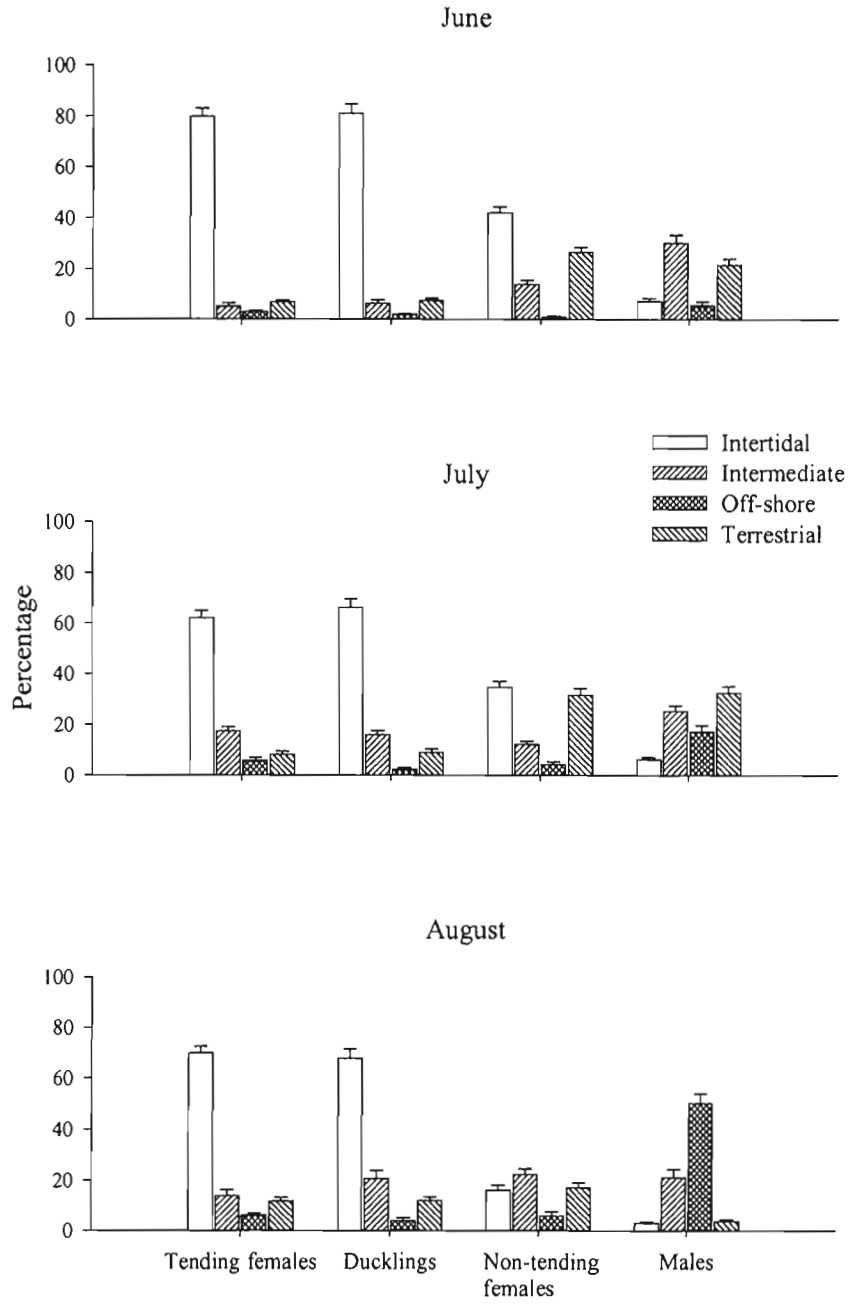

Fig. 2.2: Location of Common Eiders in relation with the distance from shore, from June to August 2004 in the St. Lawrence estuary in Quebec, Canada. Sample size varied between 38 and 67 zones with at least one observation of eiders during each period.

Table 2.1: Behaviour occurrence of Common Eider according to environmental factors along the St. Lawrence estuary, Quebec, Canada. Regression coefficients (±SE) are presented for each significant variable entered in the model.

Behaviour	Category	Summer month	Statistical model	R^2	F	df	P
Foraging	Maternal females	June	- 0.32 Sinuosity (±0.11) ** - 0,57 Mussels (±0,19) **	0.47	10.3	2;24	<0.001
		July	0.40 Disturbance (±0.07) *** - 0.87 Mussels (±0.26) ** + 0.87 Gammarids (± 0.37) *	0.55	9.7	3;24	<0.001
		August	- 1.17 Mussels (±0.27) *** + 1.43 Gammarids (±0.40) **	0.53	11.1	2;21	<0.001
	Ducklings	June	- 0.43 Sinuosity (±0.12) **	0.35	12.8	1;24	<0.01
		July	0.20 Disturbance (±0.08) * - 0.62 Littorinids (±0.21) **	0.38	7.0	2;24	<0.01
		August	- 0.94 Mussels (±0.41) * - 1.37 Littorinids (±0.57) * + 3.66 Gammarids (±0.74) ***	0.57	8.2	3;21	<0.001
	Non-tending females	June	0.08 Disturbance (±0.02) ** - 0.34 Sinuosity (±0.10) **	0.40	10.5	2;33	<0.001
		July	0.18 Disturbance (±0.05) ** - 1.42 Mussels (±0.21) *** + 0.84 Littorinids (±0.21) ***	0.59	14.9	3;33	<.0001
		August	0.05 Disturbance (±0.01) **	0.28	11.0	1;29	<0.01
Loafing	Maternal females	June	0.63 Mussels (±0.14) ***	0.45	19.0	1;24	<0.001
		July	- 0.13 Disturbance (±0.06) * + 0.67 Mussels (±0.18) ***	0.38	6.6	2;23	<0.01
		August	0.99 Mussels (±0.18) *** - 0.74 Gammarids (±0.3) *	0.56	14.4	2;24	<.0001
	Non-tending females	June	- 0.09 Disturbance (±0.02) *** + 0.64 Mussels (±0.21) **	0.47	13.8	2;33	<.0001
		July	- 0.13 Disturbance (±0.05) * + 1.32 Mussels (±0.20) *** - 0.50 Littorinids (±0.20) *	0.60	15.5	3;33	<.0001
		August	- 0.07 Disturbance (±0.01) *** + 0.42 Mussels (±0.17) * - 0.48 Littorinids (±0.17) *	0.53	10.7	3;31	<.0001
	Males	June	0.27 Sinuosity (±0.09) **	0.22	8.3	1;30	<0.01
		July	- 0.17 Disturbance (±0.05) ** + 1.39 Littorinids (±0.30) *** - 1.07 Gammarids (±0.29) **	0.66	11.5	3;20	<0.001
		August	- 0.25 Disturbance (±0.11) *	0.23	5.3	1;18	<0.05

* P<0.05; ** P<0.01; *** P<0.001

CONCLUSION GÉNÉRALE

La population d'Eiders à duvet de l'estuaire du Saint-Laurent est surveillée depuis les années soixante-dix principalement sur ses sites de nidification. Les fluctuations inexpliquées du nombre des femelles nicheuses année après année nécessitent des recherches de la communauté scientifique afin de comprendre ce phénomène. Cette population est très fragile et sensible à la moindre perturbation de leur environnement de par son faible effectif (comparé aux autres populations de sauvagine nord américaines), son grégarisme au moment de la reproduction et sa proximité de zones à haute présence humaine. La période critique d'élevage des jeunes n'a pas été étudiée depuis l'étude de Bédard et al. (1986). Depuis ce temps, les rives du fleuve Saint-Laurent ont vu un développement des activités humaines récréatives et immobilières. Il était important de déterminer si les Eiders à duvet utilisent toujours les mêmes sites préférentiels d'élevage des jeunes et si c'est le cas, dans quelles conditions.

Sélection et utilisation de l'habitat

Dans notre premier chapitre, nous avons déterminé que les Eiders à duvet se répartissaient différemment selon leur sexe et le statut maternel des femelles. Les groupes familiaux privilégiaient les zones riches en littorines (leurs proies préférentielles) proches des îles de nidification sans doute pour minimiser les coûts énergétiques reliés aux déplacements après l'éclosion. Les mâles adultes sélectionnaient des aires de mue riches en moules bleues (leurs proies préférentielles) donc situées plus en aval. Les femelles adultes qui ne s'occupent pas de jeunes suivent les groupes familiaux au début de l'été puis sélectionnaient des sites de mue semblables à ceux des mâles. Dans tous les cas, les ressources alimentaires

semblaient majoritairement influencer la sélection des habitats d'élevage des jeunes et de mue.

Dans le deuxième chapitre, nous avons décrit le budget de temps diurne propre à chaque catégorie d'eiders à duvet. Les groupes familiaux étaient majoritairement en recherche de nourriture durant la journée supposément à cause de la grande demande énergétique requise par les femelles après l'éclosion et par la croissance des canetons pendant tout l'été. Ils étaient localement répartis dans la zone intertidale ce qui coïncide avec le schéma d'abondance de leurs proies préférentielles. Les mâles se reposaient pendant la majorité du temps au moment de leur mue et se répartissaient sur la berge ou au large des rives selon le moment de l'été et supposément selon le stade de mue. Les femelles qui ont été observées sans jeunes suivaient le même patron de comportement et de localisation que les groupes familiaux juste au début de l'été, puis celui des mâles au mois d'août. Le dérangement humain augmente le temps que les oiseaux passent à rechercher leur nourriture peut-être par une augmentation de la vigilance et donc une diminution de la réussite de capture de proies. De plus, il diminue le temps que les adultes sans jeunes passent à se reposer, pouvant ainsi entraîner des délais dans le patron de mue. Le découpage de la côte affecte l'utilisation des rives par les groupes familiaux qui privilégiaient les zones sinueuses sans doute plus abritées des vents et courants. En conclusion, les comportements et localisations propres à chaque catégorie d'eiders à duvet semblaient suivre leurs besoins énergétiques et le schéma de répartition des proies préférentielles durant l'été. Cependant, des variables comme le dérangement humain et la sinuosité de la côte avaient aussi une influence sur ces paramètres donc sur l'utilisation locale des sites d'élevage des jeunes et de mue des adultes par l'Eider à duvet.

Implications pour l'aménagement

Les Eiders à duvet de l'estuaire du Saint-Laurent semblent occuper les mêmes sites

d'élevage et de mue que dans les années soixante-dix. Même si les ressources alimentaires sont le principal critère de sélection de ces sites, nous avons vu que le dérangement humain avait un effet sur leur comportement. La plasticité comportementale exprimée par de nombreux organismes vivants est très utile quand il s'agit de réagir à de nouveaux facteurs présents dans leur environnement. Cependant, on peut se demander quel va être le seuil de plasticité démontré par les Eiders à duvet en réponse à l'accroissement de la présence humaine le long de l'estuaire du Saint-Laurent. Également, à partir de quel moment le dérangement humain va-t-il être trop important pour que l'oiseau adopte un comportement compensatoire et que cela entraîne un impact négatif sur son cycle vital. La seule présence d'animaux sur un site ne signifie pas forcément que leur utilisation de ce site sera optimale pour répondre à leurs besoins. De plus, ces résultats soulignent l'importance de conserver l'intégrité des meilleurs sites offrant une abondance de ressources alimentaires. L'aquaculture et le ramassage d'algues est en développement le long des rives du fleuve Saint-Laurent. Les impacts que ces activités pourraient avoir sur la répartition et l'abondance des moules bleues pour les eiders adultes et des littorines pour les groupes familiaux pourraient directement se répercuter sur la population d'Eiders à duvet.

Ces données s'intègrent directement au plan de gestion de l'Eider à duvet soutenu par plusieurs organismes gouvernementaux et non gouvernementaux. Nous avons pu cerner les principaux sites d'élevage des jeunes et de mue des adultes. Il est maintenant primordial d'appliquer des mesures de conservation pour protéger ces sites. La plupart des abords des rives du fleuve sont des terrains résidentiels privés. La première mesure à prendre serait donc d'informer et d'éduquer le public sur la problématique des Eiders à duvet de l'estuaire. Les activités récréatives du type kayak de mer sont de plus en plus populaires et une prise de conscience sur les comportements à adopter en présence de ce canard de mer serait essentielle.

ANNEXE A

DYNAMIQUE DES GROUPES FAMILIAUX D'EIDERS A DUVET LE LONG DE L'ESTUAIRE DU SAINT-LAURENT ET SURVIE DES JEUNES

L'amalgamation des jeunes après l'éclosion est un phénomène courant chez les Anatidés (Eadie et al 1988). Malgré tout, beaucoup d'espèces se différencient par les proportions d'amalgamation rencontrées durant cette période. L'eider à duvet présente cette caractéristique très fréquemment (Munro et Bédard 1977; Öst 1999). Dans cette annexe, nous décrivons les caractéristiques d'amalgamation des jeunes chez l'eider à duvet de l'estuaire du Saint-Laurent, au Québec.

Les observations d'eiders à duvet ont été menées de juin à août 2003 et 2004. Nous avons réalisé deux inventaires par semaine (15 en 2003 et 17 en 2004) au moyen d'un télescope, depuis la rive. Le nombre et l'âge des jeunes accompagnant chaque femelle maternelle étaient notés dans chacune des 68 zones de l'aire d'étude regroupées en 4 régions. Le nombre de jeunes eiders éclos a été estimé à l'aide de plusieurs paramètres. Le nombre de nids d'une majorité d'îles provient des inventaires annuels réalisés par Duvetnor en 2003 et 2004. La taille moyenne de ponte chez l'eider à duvet de l'estuaire du Saint-Laurent est de 3.73 œufs par nid, moyenne pondérée issue de Milne et Reed (1974). Enfin, le succès d'éclosion représente le nombre de jeunes éclos sur le total d'œufs produit soit 33.8% (Milne et Reed 1974). L'estimation du nombre de jeunes eiders éclos nous permet de constater que durant notre étude, moins de 15% des canetons éclos sont aperçus à l'âge IA (1-7 jours) sur les sites d'élevage le long de la rive sud du fleuve Saint-Laurent (12.6% en 2003 et 6.4% en 2004, Fig. A.1). Par la suite, le nombre de jeunes IIA (19-27 jours) observés

par rapport au nombre de IA est de 51% en 2003 et 68% en 2004. De plus, Gauthier et Bédard (1976) ont rapporté que 93% des femelles maternelles marquées sur les îles et revues se rendaient sur la rive sud. Donc même si on considère que nous n'avons réellement inventorié que la moitié des canetons de l'estuaire dû aux conditions d'observation, un grand nombre de jeunes eiders ne sont toujours pas observés. Ceci confirme que la mortalité chez les canetons d'eider à duvet est importante et se fait principalement durant les premiers jours de vie, entre le temps de l'éclosion et l'arrivée sur les sites d'élevage le long des rives du fleuve.

Les groupes familiaux d'eiders à duvet étaient plus gros et plus nombreux en 2003 qu'en 2004 quelque soit la région de nidification (ANOVA, $F_{1;4577} = 66,2$; $P<0.0001$; Fig. A.2). La proportion de groupes familiaux de plus de quatre canetons était aussi plus importante en 2003 qu'en 2004. Il existe une tendance identique pour toutes les régions de nidification entre les deux années pour chaque caractéristique. Le nombre de groupes familiaux augmente à partir du début juin jusqu'à l'atteinte d'un pic vers la mi-juillet, puis redescend jusqu'à la fin août. Le nombre moyen de jeunes par groupe familial diminue tout au long de l'été. Enfin, au début de juin, près de 80% des groupes familiaux avaient plus de quatre canetons et cela dans toutes les régions de nidification. Cette proportion diminue pour atteindre à la fin de l'été, environ 40% en 2003 et 20% en 2004.

L'amalgamation de couvées se produit surtout au tout début de la période d'élevage le long de l'estuaire du Saint-Laurent. Cependant les différences rapportées selon les régions d'élevage montrent que ce phénomène est très variable et doit être influencé par plusieurs paramètres environnementaux en plus de la particularité de chacune des femelles.

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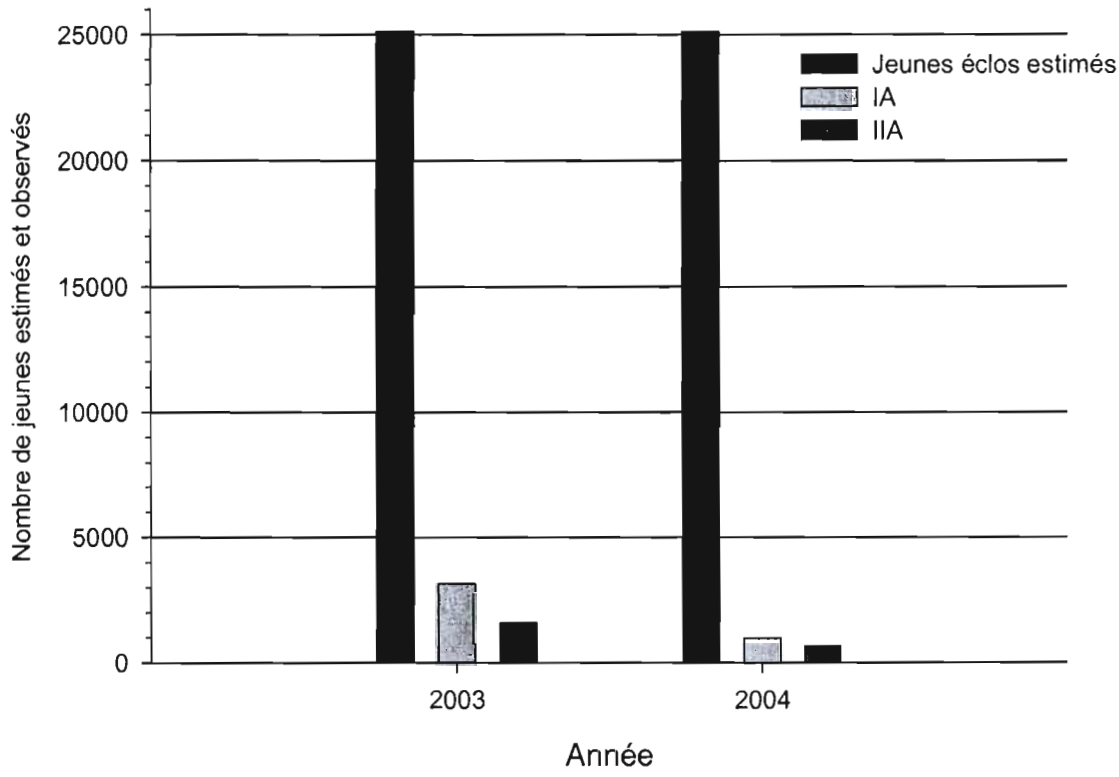

Fig. A.1 : Nombre de canetons estimés et observés pendant les inventaires de 2003 et 2004 selon leur âge le long de l'estuaire du Saint-Laurent, Québec, Canada. IA (1-7 jours) et IIA (19-27 jours) sont deux classes d'âge issues de Gollop et Marshall (1954). Le nombre de jeunes à l'éclosion a été estimé à partir du nombre de nids observés sur les îles de nidification et des paramètres démographiques publiés dans la littérature. Voir le texte pour les détails

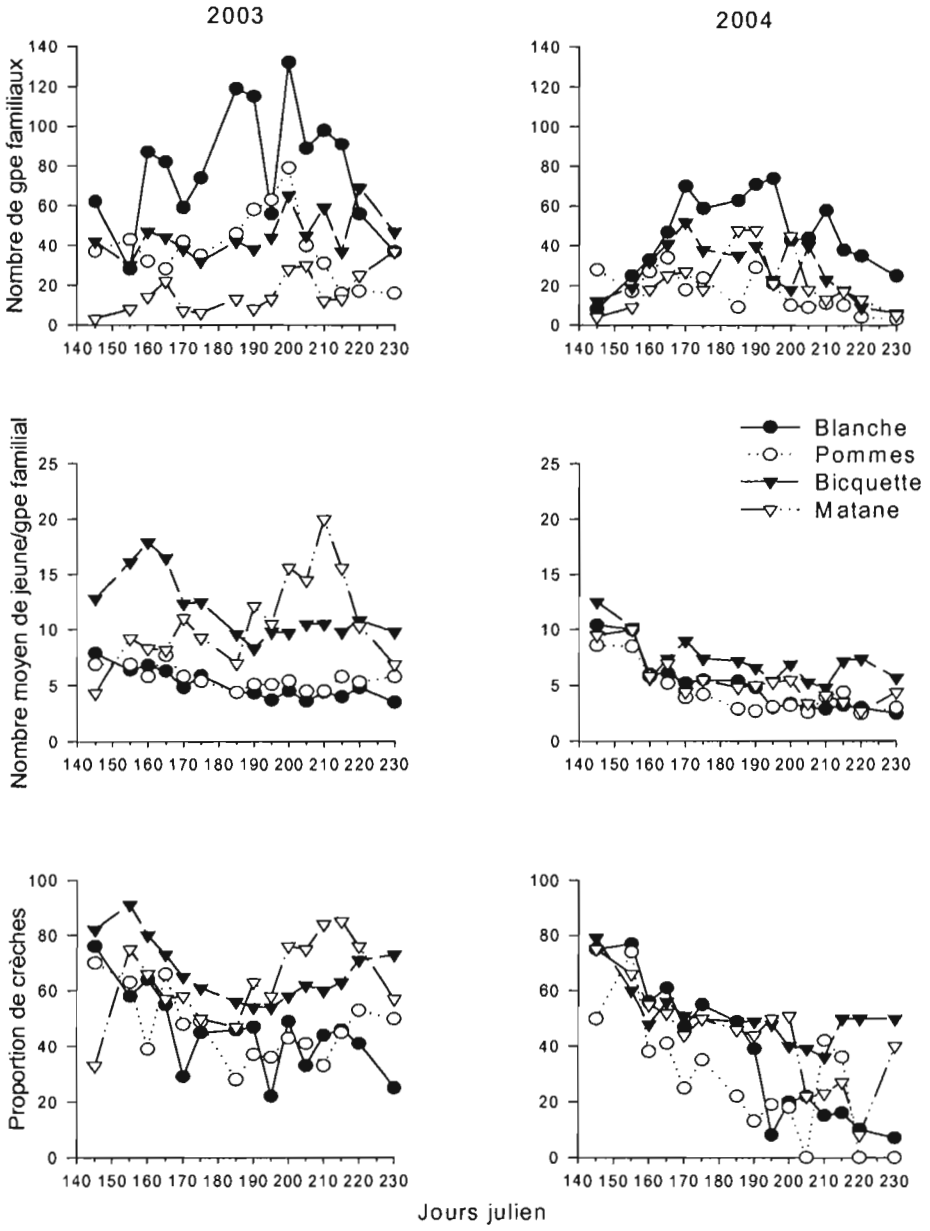

Fig. A.2 : Nombre de groupes familiaux, nombre moyen de canetons par groupe familial et proportion de crèches (groupes familiaux > 4 jeunes) selon la région géographique et la période de l'été. Les effectifs de groupes familiaux varient entre 40 et 501 selon la date, la région et l'année. Le jour 140 correspond au 20 mai et 200 au 19 juillet.

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